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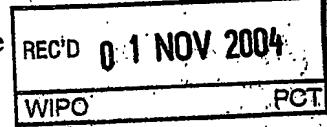
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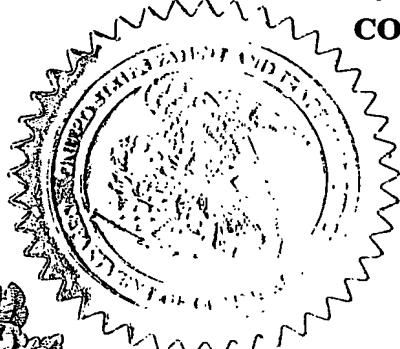
APPLICATION NUMBER: 60/516,859

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This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

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INVENTOR(S)

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Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (280 characters max)

ELECTROPHORETIC DISPLAY INCLUDING COMPRESSION/DECOMPRESSION MEANS FOR IMPROVING THE MEMORY STORAGE DENSITY

CORRESPONDENCE ADDRESS

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ENCLOSED APPLICATION PARTS (check all that apply)

- | | | | |
|---|----|--|--|
| <input checked="" type="checkbox"/> Specification Number of Pages | 17 | <input type="checkbox"/> CD(s), Number | |
| <input checked="" type="checkbox"/> Drawing(s) Number of Sheets | 2 | <input type="checkbox"/> Other (specify) | |
| <input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76 | | | |

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)

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| <input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. | FILING FEE
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

No.

Yes, the name of the U.S. Government agency and the Government contract number are: _____.

Respectfully submitted,
SIGNATURE

Frank Keegan

Date 11/13/03

REGISTRATION NO.: 50,145
(if appropriate)

Docket Number: US030434

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of Atty. Docket
MARTIN J.J. JAK, ET.AL. US030434
Serial No. Group Art Unit
Filed: CONCURRENTLY Ex.

Title: ELECTROPHORETIC DISPLAY INCLUDING COMPRESSION/DECOMPRESSION
MEANS FOR IMPROVING THE MEMORY STORAGE DENSITY

Honorable Commissioner of Patents and Trademarks
Alexandria, VA 22313-1450

AUTHORIZATION PURSUANT TO 37 CFR §1.136(a)(3)
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Sir:

The Commissioner is hereby requested and authorized to treat any concurrent or future reply in this application requiring a petition for extension of time for its timely submission, as incorporating a petition for extension of time for the appropriate length of time.

Please charge any additional fees which may now or in the future be required in this application, including extension of time fees, but excluding the issue fee unless explicitly requested to do so, and credit any overpayment, to Deposit Account No. 14-1270.

Respectfully submitted,

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Electrophoretic display including compression/decompression means for improving the memory storage density

The present invention relates to a bi-stable display and, in particular, to a
5 method and apparatus for improving the storage density of data used in such displays.

Display devices of this type are typically electrophoretic displays used, for example, in monitors, laptop computers, personal digital assistants (PDA's), mobile telephones and electronic books, newspapers, magazines, etc.

An electrophoretic display comprises an electrophoretic medium (electronic
10 ink) containing charged particles in a fluid, a plurality of display elements (pixels) arranged in a matrix, first and second electrodes associated with each pixel, and a voltage driver for applying a potential difference to the electrodes of each pixel to cause charged particles to occupy a position between the electrodes, depending on the value and duration of the applied potential difference, so as to display an image or
15 other information.

A display device of the type mentioned in the opening paragraph is, for example, known from international patent application WO 99/53373 WO, published April 9, 1999, by E Ink Corporation, Cambridge, Massachusetts, US, and entitled Full Color Reflective Display With Multichromatic Sub-Pixels. That patent application
20 discloses a display comprising two substrates, one of which is transparent. The other substrate is provided with electrodes arranged in rows and columns. A crossing between a row and a column electrode is associated with a display element or pixel. The display element is coupled to the column electrode via a thin-film transistor (TFT), the gate of which is coupled to the row electrode. This arrangement of display
25 elements, TFT transistors and row and column electrodes jointly forms an active matrix. Furthermore, the display element comprises a pixel electrode. A row driver selects a row of display elements and the column driver supplies a data signal to the selected row of display elements via the column electrodes and the TFT transistors. The data signal corresponds to graphic data to be displayed.

30 Furthermore, electrophoretic ink is provided between the pixel electrode and a common electrode provided on the transparent substrate. The electrophoretic ink comprises multiple microcapsules of about 10 to 50 microns. Each microcapsule comprises positively charged white particles and negatively charged black particles suspended in a fluid. When a negative field is applied to the common electrode, the

white particles move to the side of the microcapsule directed to the transparent substrate, and the display element becomes visible to a viewer. Simultaneously, the black particles move to the pixel electrode at the opposite side of the microcapsule where they are hidden from the viewer. By applying a negative field to the pixel 5 electrode, the black particles move to the common electrode at the side of the microcapsule directed to the transparent substrate, and the display element appears dark to a viewer. When the electric field is removed, the display device remains in the acquired state and exhibits a bi-stable character.

Recent developments in electrophoretic display technology focuses attention 10 on improving the storage density of data used in such displays so as to achieve accurate greyscale reproduction. Greyscale in the display device images can be generated by controlling the amount of particles that move to the counter electrode at the top of the microcapsules. For example, the energy of the positive or negative electric field, defined as the product of field strength and time of application, controls 15 the amount of particles moving to the top of the microcapsules to bring the display element to a desired optical state. It should be appreciated, however, that these displays are strongly influenced by image history, dwell time, temperature, humidity, lateral inhomogeneity of the electrophoretic foils, etc, all of which conspire to bring the display element to something other than the desired optical state. In particular, to 20 offset these and other factors and bring a display element to a desired optical state, a matrix look-up table (LUT) or transition matrix is required. This matrix will have one dimension each for the desired final state, and for each of the other states (initial and any prior states). Depending upon the number of prior states to be considered, which can vary with the driving method, the look-up tables (LUTs) used may become very 25 large. To take an extreme example, consider a process for a 256 (2^8) gray level electrophoretic display using an algorithm that takes account of an initial, final and two prior states. The necessary four-dimensional look-up table (LUT) has 2^{32} entries. If each entry requires 64 bits (8 bytes), the total size of the LUT would be approximately 32 Gbyte. Moreover, if the LUT were to then be compensated for 30 temperature, it is then required to generate and store look-up-tables (LUT's) for different temperatures which are usually pre-determined, measured and stored in the display controller itself and in an external memory.

It is an object of the present invention to provide a display in which the storage limitations of the prior art are overcome.

It is a further object of the present invention to provide a display in which the storage density of data is improved.

A still further object of the present invention is to provide a display in which the improved storage density of data allows for accurate grey scale reproduction
5 which considers one or more prior states of the device,

A further object of the present invention is to provide a display in which the improved storage density of data allows for accurate grey scale reproduction through compensation of temperature variations over a wide temperature range.

These and other objectives are achieved by the invention by providing a
10 display

including compression means for temporarily compressing incoming image information. The display further includes decompression means which decompress the temporarily compressed data, in a reverse operation, to generate necessary drive parameters. The display further includes a controller for retrieving waveform and
15 time parameters from a look-up table and applying the waveform and time parameters to effect a change of the display elements from a current optical state to a predetermined next optical state in dependence upon the image information received in a current frame (N) and decompressed image information received in at least one prior frame (N-1) (e.g., alternative embodiments may consider two or more prior
20 frames, N-2, N-3 and so on).

According to one aspect of the invention, the compression means used by the invention could be any well-known lossless or lossy compression algorithm.

According to another aspect of the invention, the compression/decompression processes occur in a time interval which is insignificant relative to the time required to
25 generate the necessary drive parameters in each frame.

The foregoing features of the present invention will become more readily apparent and may be understood by referring to the following detailed description of an illustrative embodiment of the present invention, taken in conjunction with the accompanying drawings, where:

30 FIG. 1 illustrates an electrophoretic display device 1 in conformance with a first embodiment of the invention; and

FIG. 2 illustrates an electrophoretic display device 1 in conformance with a second embodiment of the invention.

In the following description of embodiments of the present invention, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the described embodiments of the present invention.

Definitions

The term "grey state" or "grey scale" is used herein in its conventional meaning in the imaging art to refer to a state intermediate two extreme optical states of a pixel, and does not necessarily imply a black-white transition between these two extreme states. For example, several of the patents and published applications referred to below describe electrophoretic displays in which the extreme states are white and deep blue, so that an intermediate "gray state" would actually be pale blue. Indeed, as already mentioned the transition between the two extreme states may not be a color change at all.

The terms "bistable" and "bistability" are used herein in their conventional meaning in the art to refer to displays comprising display elements having first and second display states differing in at least one optical property, and such that after any given element has been driven, by means of an addressing pulse of finite duration, to assume either its first or second display state, after the addressing pulse has terminated, that state will persist for at least several times, for example at least four times, the minimum duration of the addressing pulse required to change the state of the display element. It is shown in copending application Ser. No. 10/063,236, filed Apr. 2, 2002 (see also the corresponding International Application Publication No. WO 02/079869) that some particle-based electrophoretic displays capable of gray scale are stable not only in their extreme black and white states but also in their intermediate gray states, and the same is true of some other types of electro-optic displays. This type of display is properly called "multi-stable" rather than bistable, although for convenience the term "bistable" may be used herein to cover both bistable and multi-stable displays.

The discussion below concentrates upon one or more pixels of an electrophoretic display undergoing a gray scale transition, i.e., a change from one gray level to another, from an "initial" state to a "final" state. Obviously, the initial state and the final state are so designated only with regard to the transition being

considered at a particular point in time and it is to be understood that the pixel has undergone transitions prior to the "initial" state and will undergo further transitions after the "final" state.

Where it is necessary to distinguish between multiple prior states, the term
5 "first prior state" will be used to refer to the state in which the relevant pixel existed
one (non-zero) transition prior to the initial state, the term "second prior state" will be
used to refer to the state in which the relevant pixel existed one (non-zero) transition
prior to the first prior state, and so on.

Overview

10 As described above, bi-stable displays act, to a first approximation, as impulse
transducers, so that the final state of a pixel depends not only upon the electric field
applied and the time for which this field is applied, but also upon the state of the pixel
prior to the application of the electric field. The state of the pixel prior to the present
application of an electric field is the result of the pixel's image history, defined as the
15 total energy (or stress), i.e., voltage x time, seen by each pixel over time.

As is well known to those in the display art, image information is provided to
an electrophoretic display device in a series of consecutive frames, i.e., 1, 2, ..., N-1,
N, N+1, N+2, and so on At each frame, a drive parameter (voltage x time) is
generated for each display element of the display. The drive parameter is determined
20 in part from the image information provided in the current frame N (i.e., current state)
and the image history of the element for some number of prior states. In one
embodiment, image information is considered from the current state (frame N) and
one prior state (frame N-1) to generate the necessary drive parameters to effect a
change of the display elements from a current optical state to a predetermined next
25 optical state.

Generally, it is well known that bi-stable devices have a strong image history,
and as a consequence, accurate grey scale reproduction requires data from as many
prior states as possible. Further, when the device is compensated for temperature
variations, the data requirements grow in proportion. As one example, to adjust a
30 device for a temperature range of -22C to +80C with a 1/2 degree resolution, over two-
hundred temperature compensation look-up tables are required. It is therefore
apparent that the data requirements pose an enormous challenge in terms of
minimizing the memory requirements and cost of a device.

By way of background, it is well known that many different data compression techniques exist in the prior art. Compression techniques can be divided into two broad categories, lossy coding and lossless coding.

A lossless compression technique compresses data without loss of the data so as to restore the compressed data to the original data, but there is a limit to a compression rate of the lossless compression algorithm. Thus, a lossless compression algorithm is generally employed in compressing a document file and a program file. (e.g., Huffman Coding, Run Length Encoding, LZW, etc.)

Conversely, a lossy compression technique compresses data by deleting relatively insignificant parts of the data, thereby decreasing the size of the data. Thus, the compression rate of the lossy compression algorithm is much higher than the compression rate of the lossless compression algorithm, but it is impossible to perfectly restore compressed data to the original data. Thus, the lossy compression algorithm is generally employed in compressing audio and video files. (e.g., JPEG, MPEG, etc.).

In addition to the well known compression schemes, the invention also contemplates the use of a low-complexity scalable image compression algorithm based on the 8x8 block discrete cosine transform (DCT). Unlike a conventional DCT compression algorithm, the low-complexity scalable image compression algorithm uses no additional quantization or entropy. For a fuller discussion of this algorithm, "Low-Complexity Scalable Image Compression", Rene J. van der Vleuten, Richard P. Kleihorst, which is incorporated by reference.

First Embodiment

FIG. 1 illustrates an electrophoretic display device 1 in conformance with a first embodiment of the invention. The display device 1 of FIG. 1 includes a frame memory 9, a compression unit 3, a decompression unit 5, a display controller 7, a memory for storing a look-up table 12, a temperature sensor 13 and a display device 15 comprised of a plurality of electrophoretic display elements 18. The display device 1 performs real time data compression/decompression on receive image information (frame data), as will be described.

With continued reference to FIG. 1, in operation, image information (frame data) is provided to the electrophoretic display device 1 in a series of consecutive frames, i.e., 1, 2, .., N-1, N, N+1, N+2,... and so on, at successive time intervals. For example, frame data for the N-1th frame is received and processed at time T₋₁; then in

successive order, frame data for the N^{th} frame is received and processed at time interval T_0 ; frame data for the $N+1^{\text{th}}$ frame is received and processed at time T_{+1} and so on.

For ease of explanation, the process will be described in greater detail starting 5 at time T_0 at which point the N^{th} frame data is received at input node 2 and processed by the electropheretic display device 1.

At time T_0 , frame data associated with the current frame, referred to hereafter 10 as N^{th} frame data, is received at input node 2 of the display device 1. The N^{th} frame data is processed substantially simultaneously in two ways. First, the N^{th} frame data is supplied to the compression unit 5 under control of the display controller 7. The compression unit 5 processes the N^{th} frame data and outputs compressed N^{th} frame data to be stored in the frame memory 9 under control of the display controller 7.

Second, substantially simultaneous with the operation of compressing and 15 storing the N^{th} frame data, the display controller 7 is further arranged to use the N^{th} frame data, and data corresponding to at least one prior state, to generate drive parameters 20 to effect a change of the display elements from a current optical state (first gray scale or color value) to a predetermined next optical state (second gray scale or color value).

In one embodiment, the necessary drive parameters 20 are derived in 20 dependence on the current N^{th} frame data and one prior state, i.e., the $(N-1)^{\text{th}}$ frame data received in the previous frame, i.e., at time T_{-1} . It is noted that in order to utilize the $(N-1)^{\text{th}}$ frame data, it must first be retrieved from memory 9, where it has been previously stored in compressed form in the previous time interval, and decompressed by decompression unit 5 under control of the display controller 7.

As described above, in the present exemplary embodiment, display controller 25 7 is arranged to generate the drive parameters 20 (waveform and time parameters) for the display elements 18 in dependence upon the image information received in the current frame, N^{th} frame data, and the stored frame data (image information) corresponding to one previous state, $(N-1)^{\text{th}}$ frame data. Each state corresponds to a 4- 30 bit number corresponding to a 16-level grey scale. These bits together form an 8 bit entry in the LUT 12. Preferably, the LUT 12 has address entries corresponding to at least one previous state of the display element and the current state of the display elements.

It is to be appreciated that in alternate embodiments, the waveform and time parameters may be generated in dependence upon additional prior states. For example, the drive parameters 20 may be generated in dependence on the Nth frame data received at time T₀, and two prior states, i.e., the (N-1)th and (N-2)th frame data 5 received at respective time intervals T₋₁ and T₋₂. It is noted that at time T₀, the (N-1)th and (N-2)th frame data have been previously stored in the frame memory 9 in compressed form at respective times T₋₁ and T₋₂. The previously stored frame data and must first be decompressed for use in determining the necessary drive parameters 10 20 at time T₀. In addition to decompressing the required frame data, the present invention further conserves frame memory 9 by adding and deleting frames at each frame in accordance with a last-in-first-out (LIFO) protocol. For example, at time T₀, frame (N) data is stored in compressed form in the frame memory 9 and the least most recently added frame, frame (N-2) data, in the illustrative example, is purged from the frame memory 9. It is further noted, while the frame (N-1) data is decompressed for 15 use at this time, it is not purged from the frame memory 9 until the next time interval T₊₁ in LIFO like manner.

Those of skill in the art will appreciate that for the compression/decompression processes described herein, it is possible to have near lossless compression and decompression. However, in the preferred embodiment, 20 some controlled loss is accepted in order to further optimize the process (e.g., avoid adding precision that would not result in better image display quality, as perceived by the user).

As shown in FIG. 1, the display device 1 also includes a digital temperature sensor 13 for sensing an operating temperature of the device and for providing a 25 temperature compensation in order to reduce the temperature dependency of the grey value reproduction of the display device. To this end, the temperature sensor 13 generates, for example, a 4-bit number representing an actual operating temperature of the display device, and the address entry of the LUT 12 is extended with additional bits. It is noted that while the LUT 12 is shown in a separate memory 11, it can be 30 realized in the same memory as the frame memory 9 in certain embodiments.

Table I is provided to further illustrate the method of the invention for compressing/decompressing frame data at each frame and generating the necessary drive parameters therefrom.

Reference is made to the second row of Table I. At time T_0 , data received in the current frame (N), i.e., frame (N) data, is received at input node 2. At this time, the frame (N) data is stored in the memory 11, in compressed form (second column), and is also used substantially simultaneously as received (i.e., in uncompressed form),

5 to generate the necessary drive parameters 20 to effect a change of the display elements 18 from a current optical state to a predetermined next optical state. It is noted that, in the illustrative embodiment, the drive parameters 20 are generated in dependence on both the frame (N) data and frame data corresponding to at least one prior state, i.e., frame (N-1) data (column 4). Substantially coincident with the

10 operations described, frame (N-2) data is purged from the memory 9 in accordance with the LIFO protocol (column 3).

Table I.

Time	Received data	Stored data (in compressed form)	Purged frame data	Frame data required to generate necessary drive parameters
T_{-1}	$N-1^{\text{th}}$ frame data	$N-1^{\text{th}}$ frame data	$N-3^{\text{th}}$ frame data	$N-1^{\text{th}}$ frame data $N-2^{\text{th}}$ frame data
T_0	N^{th} frame data	N^{th} frame data	$N-2^{\text{th}}$ frame data	N^{th} frame data Frames $N-1^{\text{th}}$ frame data
T_{+1}	$N+1^{\text{th}}$ frame data	$N+1^{\text{th}}$ frame data	$N-1^{\text{th}}$ frame data	$N+1^{\text{th}}$ frame data N^{th} frame data Frames

15 The generated drive parameters 20 may consist of pulses of fixed duration and varying amplitude, pulses with a fixed amplitude, alternating polarity and a varying duration between two extreme values, and hybrid drive signals wherein both the pulse length and the amplitude can be varied. For a pulse amplitude drive signal, this predetermined drive parameter indicates the amplitude of the drive signal including

20 the sign thereof. For a pulse time modulated drive signal, the predetermined drive parameter indicates the duration and sign of the pulse making up the drive signal. For a hybrid generation or pulse-shaped drive signal, the predetermined drive parameter indicates the amplitude and the length of portions making up the drive pulse. The predetermined drive parameter may be, for example, an 8-bit number. For each entry

25 in the look-up table 12, the drive parameter is experimentally determined for a

selected type of electronic ink for a corresponding grey level transition and different predetermined operating temperatures.

Second Embodiment

Yet another embodiment of the invention is shown in FIG. 2. In the present embodiment, in addition to compressing image information to improve memory storage density, the present embodiment compresses the look-up table data (LUT) 12 to achieve further memory storage density.

As shown in FIG. 2, the display 1 includes all of the elements of the display of FIG. 1 and further includes a second compression unit 15 and a second decompression unit 17, which respectively compress and decompress the look-up table data. It is noted that because the look-up table data constitutes a smaller percentage of the overall data requirements of the display 1, the improved storage density realized by compressing the look-up data is not as significant as compressing the voluminous frame data (image information) described in the previous embodiment.

It is further noted that alternative embodiments may utilize a plurality of look-up tables, instead of the single LUT 12 shown, to compensate for wide temperature variations which may be experienced by the device 1. For example, to adjust the device 1 for a temperature range of -22C to +80C with a ½ degree resolution, over two-hundred temperature compensation look-up tables (LUTs) are required. The plurality of temperature compensation LUTs may be preferably stored in compressed form in the memory 11. In use, upon determining the temperature of the display device 1, the LUT 12 from among the plurality of stored LUTs corresponding to the detected temperature of the device 1 is identified, decompressed and used to generate the drive parameters 20 in the manner described above under control of the display controller 7.

It is noted that in each of the embodiments, the compression and decompression units 3, 5, 15 and 17 can be incorporated into the display controller 7. That is, the functionality of the compression and decompression units may be incorporated into the display controller, thereby removing the need to utilize stand-alone devices, as described in the previous embodiments.

Conclusion

In conclusion, as will be evident from the above description, the electrophoretic display device, in accordance with embodiments of the invention, improves the storage density of data used in such display devices. Further, the time

required to perform the compression/decompression processes are insignificant relative to the operation of generating drive parameters in each consecutive frame. By compressing image information and/or LUT data in the device, accurate grey scale reproduction may be achieved at a reasonable cost.

5 Finally, the above-discussion is intended to be merely illustrative of the present invention and should not be construed as limiting the appended claims to any particular embodiment or group of embodiments. For example, the controller 7 may be a dedicated processor for performing in accordance with the present invention or may be a general-purpose processor wherein only one of many functions operates for
10 performing in accordance with the present invention. The processor may operate utilizing a program portion, multiple program segments, or may be a hardware device utilizing a dedicated or multi-purpose integrated circuit. Each of the systems utilized may also be utilized in conjunction with further systems. Thus, while the present invention has been described in particular detail with reference to specific exemplary
15 embodiments thereof, it should also be appreciated that numerous modifications and changes may be made thereto without departing from the broader and intended spirit and scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative manner and are not intended to limit the scope of the appended claims.

20 In interpreting the appended claims, it should be understood that:
 a) the word "comprising" does not exclude the presence of other elements or acts than those listed in a given claim;
 b) the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements;
25 c) any reference numerals in the claims are for illustration purposes only and do not limit their protective scope;
 d) several "means" may be represented by the same item or hardware or software implemented structure or function; and
 e) each of the disclosed elements may be comprised of hardware portions
30 (e.g., discrete electronic circuitry), software portions (e.g., computer programming), or any combination thereof.

CLAIMS:

1. An electrophoretic display (1), comprising:
a display device (15) further comprising a plurality of display elements
(18);
input means (2) for receiving image information in consecutive frames;
first compression means (3) for compressing said received image
information to increase availability of storage in said electrophoretic display (1);
a first memory (11) storing a look-up table (12) defining waveform and
time parameters for effecting a change of the display elements (18) from a current
optical state to a predetermined next optical state;
a second memory (9) storing and deleting said compressed received
image information in accordance with a last-in-first-out (LIFO) protocol;
first decompression means (5) for decompressing said compressed
received image information; and
a controller (7) configured to receive said compressed image
information
, store said compressed image information, delete said compressed information;
the controller (7) further configured to retrieve said look-up table (12)
from said first memory (11), apply said waveform and time parameters included in
said look-up table (12) to effect a change of the display elements (18) from said
current optical state to said predetermined next optical state in dependence upon
image information received in a current frame (N) and decompressed image
information received in at least one prior frame (N-1).

2. The electrophoretic display of claim 1, further comprising second
compression means (15) for compressing said look-up table (12) prior to storing said
look-up table (12) in said first memory (11).

3. The electrophoretic display of claim 1, further comprising second
decompression means (17) for decompressing said look-up table (12) stored in said
first memory (11).

4. The electrophoretic display of claim 1, further comprising a plurality
of look-up tables, each of said plurality of look-up tables indexed by temperature,

each of said plurality of look-up tables defining waveform and time parameters for effecting a change of the display elements (18) from said current optical state to said next optical state in dependence upon said image information received in said current frame (N) and image information corresponding to at least one prior frame (N-1) for a particular temperature.

5. The electrophoretic display of claim 1, further comprising second compression means (15) for compressing said plurality of look-up tables prior to storing said plurality of look-up tables in said first memory (11).

6. The electrophoretic display of claim 1, further comprising a temperature sensor (13) configured to measure a temperature indicative of a temperature of the electrophoretic display (1), transmit said measured temperature to said controller (7).

7. The electrophoretic display of claim 6, wherein said controller (7) is further configured to receive said measured temperature from said temperature sensor (13).

8. The electrophoretic display of claim 1, wherein the predetermined next optical state is a gray scale.

9. The electrophoretic display of claim 1, wherein the predetermined next optical state is a color.

10. The electrophoretic display of claim 1, wherein the compression means performs compression by a lossless compressor.

11. The electrophoretic display of Claim 10, wherein the lossless compressor applies a lossless compression algorithm to said image information received in said consecutive frames.

12. The electrophoretic display of Claim 1, wherein the compression means performs compression by a lossy compressor.

13. The electrophoretic display of Claim 12, wherein the lossy compressor applies a lossy compression algorithm to said image information received in said consecutive frames.

14. A method for improving the storage density of data in an electrophoretic display device (1) comprising the acts of:

successively receive image information in consecutive frames;

compressing said image information received in said consecutive

frames;

storing waveform and time parameters for effecting a change of the display elements (18) from a current optical state to a predetermined next optical state;

storing said compressed image information received in said consecutive frames in a second memory (9) in accordance with a last-in-first-out (LIFO) protocol;

decompressing, for a currently received frame (N), said compressed image information stored in said second memory (9) received in at least one prior frame (N-1);

retrieving, from said first memory (11), waveform and time parameters to effect a change of the display elements (18) from a current optical state to a predetermined next optical state in dependence upon said image information received in said currently received frame (N) and said decompressed image information received in said at least one prior frame (N-1); and

applying said retrieved waveform and time parameters to effect said change of the display elements (18) from said current optical state to said predetermined next optical state.

15. The method of claim 14, wherein said waveform and time parameters are stored in a look-up table (12) stored in a first memory (11).

16. The method of claim 15, further comprising the act of compressing said look-up table (12) prior to storing said look-up table (12) in said first memory (11).

17. The method of claim 14, wherein said waveform and time parameters are stored in a plurality of look-up tables, indexed by temperature, each of said look-up tables defining waveform and time parameters for effecting a change of the display elements (18) from said current optical state to said next optical state in dependence upon said image information received in said current frame (N) and image information received in said at least one prior frame (N-1) for a particular temperature.

18. The method of claim 17, further comprising the acts of:
detecting a temperature indicative of the temperature of the
electrophoretic
display device (1), wherein said retrieving act is performed by retrieving a look-up table from among said plurality of look-up tables stored in said first memory (11)
using said detected temperature as an index.

19. The method of claim 17, further comprising the act of compressing
said
plurality of look-up tables prior to storing said plurality of look-up tables in said first
memory (11).

20. The method of claim 19, further comprising the acts of:
detecting a temperature indicative of the temperature of the
electrophoretic
display device (1), wherein said retrieving act is performed by retrieving a look-up table from among said plurality of look-up tables stored in said first memory (11)
using said detected temperature as an index; and
decompressing said retrieved look-up table.

21. The method of claim 12, wherein the compression act is performed by
a by a lossless compressor.

22. The method of Claim 21, wherein the lossless compressor applies a

lossless compression algorithm to said image information received in said consecutive frames.

23. The method of Claim 12, wherein the compression act is performed by a by a lossy compressor.

24. The method of Claim 23, wherein the lossy compressor applies a lossy compression algorithm to said image information received in said consecutive frames.

25. A computer program product for improving the storage density of data in an electrophoretic display device (1), the computer program product comprising computer code devices configured to:

successively receive image information in consecutive frames;
compress said received image information to increase availability of storage in said electrophoretic display (1);

store a look-up table (12) defining waveform and time parameters for effecting a change of the display elements (18) from a current optical state to a predetermined next optical state;

store compressed received image information in accordance with a last-in-first-out (LIFO) protocol;

decompress said compressed received image information; and
apply said waveform and time parameters included in said look-up table

(12) to effect a change of the display elements (18) from said current optical state to said predetermined next optical state in dependence upon image information received in a current frame (N) and decompressed image information received in at least one prior frame (N-1).

ABSTRACT

A display device (1) is provided for improving storage density. The display device (11) is comprised of compression means (3) for temporarily compressing incoming image information data and decompression means (5) for decompressing the temporarily compressed data, in a reverse operation. By compressing the incoming image data for some number of frames, improved storage density is achieved. In this manner, the number of frames of image information available to be used in generating waveform and time parameters to effect a change of the display elements (18) from a current optical state to a predetermined next optical state is increased thus providing more accurate gray scale reproduction.

